Report of the Carnegie Mellon Symposium on Minorities in Computing

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1. Introduction

The Carnegie Mellon Symposium on Minorities in Computing meeting convened a cross-disciplinary group of experts to strategize on research and intervention programs, and to guide programs underway, aimed at enhancing the participation of under-represented minority groups in the creation of information technology. We met for two days, beginning with a framing by the hosts of the questions we wished to address. We then focused on several key topics, synthesizing the participants' expertise to make recommendations in the following areas:

- overcoming social, cultural and psychological barriers to full participation
- appropriate curriculum and pedagogy for secondary school and beyond
- building collaborations among universities, companies, schools, community organizations, etc.
- marketing CS involvement to under-represented populations
- high-impact areas for further research and intervention
- developing appropriate support for career-building and entrepreneurship

This report

- summarizes some key features of the status quo;
- recommends research priorities that will guide future strategies for closing the gap in participation among and between white men and men and women of color; and
- recommends specific intervention strategies that, pending further research, offer the greatest promise for progress in the near future.

1.1 Attendees

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1.2 Agenda

Sunday, 11/14
6:00 reception (Sheraton Station Square, Steamboat Room)
7:00 dinner, agenda overview

Monday, 11/15
8:00 continental breakfast (Sheraton Waterfront Room)
8:30 working session (including break): The Situation: problem definition
12:00 lunch (Steamboat Room)
1:30 working session (including break): Recommended Interventions
5:00 break
6:00 appetizers, dinner (Grand Concourse, Audubon Room)

Tuesday, 11/16
8:00 board bus/limo to Carnegie Mellon campus (4625 Wean Hall)
8:30 continental breakfast
9:00 working session (including break): Recommended Research: forming the agenda
12:00 lunch
1:30 wrap-up session
3:00 conclude

2. The Situation

2.1 Diversity in the academic pipeline and in the profession

Amid the extraordinary ongoing explosion of information technology (IT) and its applications, all indications are that its impact could be greater still if not for a shortage of skilled workers. Economists consider that information technology is now the nation's largest industry, grossing more than $865 billion a year.[1] Approximately 400,000 jobs are currently unfilled, and the number is increasing by about 25 percent a year. "The figure is expected to mushroom to 1.2 million vacant IT positions by 2005 if present trends continue."[2] One survey of software projects found that 40% were canceled and another 35% had serious problems, with much of the difficulty attributed to a shortage of appropriate personnel.[3] The cost to the economy of the shortage has been estimated at three billion dollars per year in Silicon Valley alone.[4] A similar shortage exists for people trained in hardware and systems development.

Despite this demand, participation of women and minorities in the creation of new hardware and software remains low. In 1998, at the nation's Ph.D.-granting departments of computer science and engineering, just 5% of bachelor's degrees, the standard credential for software jobs, go to Blacks and Hispanics of either sex, and just 15% to women.[5] Figures are higher at four-year institutions, but in 1998 the Bureau of Labor Statistics still tabulated the population of computer systems analysts and scientists as 26.9 percent female and 10.8 percent Black and Hispanic.[6] The impact of this under-representation is profound, both for individuals in the under-represented groups and for society at large. Talented individuals are missing out on great economic opportunity, and business and society are missing both the productivity and the unique perspectives those individuals could bring to the technology enterprise.

2.2 The digital divide at home

Gaps in home access are not simply a matter of economic differences. "A White, two-parent household earning less than $35,000 is nearly *three times* as likely to have Internet

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[1] Harmon, Amy (1998). "With Boom in High Technology, Software Jobs Go Begging." New York Times, January 13.

[2] Scannell, Tim (1999). "IT Worker Gap will Hit 1.2 Million by 2005." *Computer Reseller News*, June 29.

[3] Shirley Tessler & Avron Barr. Slides from the talk presented to the Enterprise Software Roundtable, September 4, 1997, citing Forbes, December 1996. http://www.stanford.edu/group/scip/avsgt/roundtable9297.pdf

[4] Joint Venture: Silicon Valley Network. "An Analysis of the Workforce Gap in Silicon Valley", May, 1999. http://www.jointventure.org/initiatives/edt/work_gap/home.html

[5] Kozen, D. and Zweben, S. (1998). "1996-1997 CRA Taulbee Survey: Undergrad Enrollments Keep Booming, Grad Enrollments Holding Their Own." *Computing Research News*, March.

[6] Bureau of Labor Statistics, U.S. Department of Labor (1999). Household Data Annual Averages, Table 11: Employed persons by detailed occupation, sex, race, and Hispanic origin.

access as a comparable Black household and nearly *four times* as likely to have Internet access as Hispanic households in the same income category."[7]

2.3 The academic and digital divide at school

Although schools hold the promise of leveling access, disparities between suburban school districts and their less affluent urban and rural counterparts are as serious in the technological arena as in infrastructure and funding in general. Studies find that affluent schools provide their students with more computers on a per pupil basis than do poor ones.[8]

Further exacerbating the infrastructure gap are disparities in teacher preparation. Access to infrastructure without preparation by teachers for effective use in learning has little benefit. Studies show that teachers of "higher-achieving" classes use the Internet more and find it more useful to their teaching and that boys and "better students" dominate computer use[9]. Studies also show that even when African-American children use computers extensively in school, they are often assigned more rote activities in contrast to the higher-level activities engaged in by majority children at school. "In eighth grade, minority, poor, and urban students are more likely to find themselves learning lower-order skills than their White, non-poor, and suburban counterparts; disadvantaged students are also less likely to find themselves learning higher-order skills."[10]

2.4 Cultural and psychological factors

Part of the lack of involvement among under-represented groups, white women included, seems to involve the attractiveness of the field, both in reality and in its popular perception. "The cultural norm of the successful [computer science] student is someone who is who is at the computer twenty-four hours a day/seven days a week ('24/7'), 'living, thinking and breathing computer science.'"[11] Furthermore, simply by virtue of their narrow demographic makeup, academic and corporate technology departments can be unintentionally unwelcoming to individuals from other backgrounds.

Members of under-represented groups are also likely to bear the brunt of stereotypes about who does, or can do, computing work. Claude Steele's research on stereotype threat offers one explanation for the link between these negative stereotypes, drops in confidence and declining interest. In his article "A Threat in the Air," Steele looks at the experiences of African Americans in higher education and women in traditionally male

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[7] National Telecommunications and Information Administration, *Falling Through the Net: Defining the Digital Divide.* Released July 8, 1999, revised November 1999. Third report in the Falling Through the Net series on the Telecommunications and Information Technology Gap in America. http://www.ntia.doc.gov/ntiahome/fttn99/contents.html

[8] H.J. Becker and C.W. Sterling, "Equity in School Computer Use: National Data and Neglected Considerations", Journal of Educational Computing Resources, 3, 289-311, 1987.

[9] Becker and Sterling, 1987.

[10] Harold Wenglinsky, "Does it Compute? The Relationship Between Educational Technology and Student Achievement in Mathematics", Educational Testing Service, 1998. http://www.ets.org/research/pic/technolog.html

[11] Jane Margolis, Allan Fisher and Faye Miller, "Geek Mythology", working paper, http://www.cs.cmu.edu/~gendergap/geekmyth.html

fields, examining what could be depressing their grades and test scores on standardized testing and in advanced math and science courses respectively. He argues that when one is in a situation in which a negative stereotype about one's group applies, one is fearful of confirming the stereotype. This creates a "stereotype threat," which can lead to poorer performance and disidentification with the field. Disidentification with a field offers "the retreat of not caring about the domain in relation to the self. But, as it protects in this way, it can undermine sustained motivation in the domain" [12]

Another key issue is the effect on motivation of implicit theories of intelligence. These provide the basis for which people interpret and understand achievement situations.[13] (Dweck, 1991; Dweck & Leggett, 1988). Implicit theories about the nature of intelligence often take one of two views, an entity view—intelligence is essentially fixed, or an incremental view—intelligence is malleable. Within each of these theories, people will be motivated towards different goals.

[12] Steele, Claude. (1997). "A Threat in the Air: How Stereotypes Shape Intellectual Identity and Performance." *American Psychologist* , 52 (6): 613-629.

[13] Dweck, S. C., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. Psychological Review, 95(256-273).

Dweck, C. S. (1991). Self -theories and goals: Their role in motivation, personality, and development. In R. Dienstbier (Ed.), Nebraska Symposium on Motivation, 1990 (Vol. 38). Lincoln: Nebraska.

3. Recommendations for Research

3.1 General exhortations

One issue that cuts across all areas of research is the need to disaggregate data pertaining to different underrepresented communities. While many issues may be common to different groups, others may vary widely from group to group. The experiences and attitudes of African-Americans differ from those of Hispanics; furthermore, the issues affecting urban African Americans are not identical to those in suburban settings, and Mexican Americans' issues are not identical to those of Puerto Rican Americans. Within these categories, the experiences and attitudes may be different for men and women. Clearly, there is a limit to the extent to which data can meaningfully be disaggregated. What is important is to recognize when a given measure crosses important community boundaries, and to attempt to confirm the extent to which an effect is truly shared.

Our second exhortation is that complex problems require systemic solutions. Enhanced recruiting of diverse populations will succeed only if institutions change to serve them well. Any given initiative will necessarily focus primarily on one area, but all should be designed with an understanding of the big picture. Similarly, no one discipline or type of institution holds the entirety of the solution; cross-disciplinary and cross-sector collaboration is critical to creating systemic solutions.

3.2 Priority research areas

We believe that the most important areas for research fall into these general categories:

- Beliefs, experiences, attitudes and learning styles: What are the patterns of access, experience, and attitudes of various minority groups in computing fields? What factors and decisions drive key decisions, from childhood through career entry? How do the preferences of various groups differ from the "norm?" The answers can inform both the "marketing" of technology studies and careers, and the restructuring of existing institutions.

- Better quantification and disaggregation of pathway and pipeline issues: What is the shape of the education and career pipeline for different groups of minority students? At what points in the pipeline are we losing minority students? What are the pathways into various types of computing careers? How might we prevent those losses, and provide opportunities to re-enter the pipeline?

- Careful study of existing programs regarding minorities in computing fields: Which have been successful and not so successful? What elements are crucial to success? What successful programs in other domains might we adapt to IT? What are the best practices?

3.3 Specific research issues

Below, we characterize research questions by the *unit of analysis* to which the question pertains. Specifically, we consider the following:

- Individual
- Family
- Community and Culture
- School and Work

3.4 Individual

Stereotype Threat

Verify the existence, and study the differential impacts across groups, of stereotype threat with respect to computing topics.

Learn more about combating stereotype threat and identifying key stages for implementing intervention (i.e. before disidentification becomes an issue - this may vary for different groups).

Conduct developmental studies to see at what ages interests, motivation and identification issues start to emerge in minority students.

Investigate how educating students about stereotype threat might affect their performance.

Attribution and Views of Intelligence

Study the sources and consequences of beliefs as to whether computing ability is innate or learned.

Study the effects of educating students about the view that intelligence, specifically CS ability, is malleable, not a fixed quantity, on their confidence and performance.

Investigate the ways that various groups attribute personal success and failure.

Personality

Learn from those who persist and succeed. (How) can a "people person" be happy in computing?

Investigate the phenomenon of retreat and isolation: who uses computers this way and why? What is true/false about the myth of obsession? When does hacking cross over into pathology?

Study the relationship between attitudes and achievement. These appear to be highly correlated for individuals belonging to some groups, but not in others.

The Appeal of Computers

Study attitudes in various ethnic groups towards technology and technological careers. What are the stereotypes about who does IT? What possibilities exist for re-shaping these attitudes?

Research suggests that computers might fulfill certain socio-psychological needs for many adolescent boys. Does this hold true across racial boundaries?

We know there are differences in the types of recreational software that engage boys and girls. What differences exist across race and ethnicity? How might the content and presentation of computer technology stir interests of groups or leave them cold?

3.5 Home and Family

The variation of computer ownership and use patterns across race and socioeconomic status have been studied, but less so its causes. How are utility and price regarded differently by different groups?

Much depends on home experience, developmentally all the way through and including critical events. What critical events/turning points for individuals happen at home?

3.6 Communities & Culture

Understand how IT improves/worsens the divide between the haves and have-nots.

Understand cultural markers of status --such as coolness and geekiness-within various communities, and how information technology careers might fit.

Understand the consequences of success for different groups. There is a sense of people having to disconnect themselves from home in a way that others don't. How do African American and Hispanic family cultures affect participation and peer culture? Is academic achievement perceived as "acting white"?

Elucidate the aspects of the prevalent computing culture that may attract or repel different groups.

Evaluate the effect of community technology centers (CTCs) and similar affinity groups on minority interest in information technology or computer science and the creation of information technology.

3.7 School and Work

Distribution of facilities and resources

Study how the culture and processes *within* schools determine which students in a given classroom actually gain effective access to technology resources.

Learning Styles

Study how distinct learning styles among different groups affect IT interest/success. Research in math (Treisman) suggests that group support and study are critical.

Study how knowledge of non-majority cultures' learning styles and preferences can be used to adapt disciplinary cultures so as to eliminate access barriers.

Gatekeepers

Investigate the *appropriate* and the *commonly applied* gatekeepers to computer science education. Do students, teachers and guidance counselors have faulty assumptions of what is needed to enter computing studies?

Define which prerequisites are in fact necessary/helpful. Are students prematurely limiting their options through course-taking decisions made early on?

Evaluate existing programs that allow people to re-enter the pipeline and compensate for gaps in their knowledge along the way, rather than remedial efforts. An example is Uri Treisman's Emerging Scholars Program[14], in which students are presented with challenging work and engaged in an ongoing learning community.

K-12

Study whether and how distinctive learning styles among different groups affect IT interest /success (solo versus group work, for example)?

Examine intra-school and intra-classroom processes that may lead to differential amounts or types of computer use among students of different backgrounds.

Look at schools and districts that are particularly successful in graduating minority students with a strong grounding in science and technology. Ex: Thomas Jefferson High School; Bronx School of Science and Technology

Post-secondary

Understand the difference in resources between minority-serving institutions and majority institutions. Are there distinctive have and have-not institutions, and how might support be better distributed?

Characterize the institutions that are top producers of minority students who go on to work in computing fields.

Explore the potential of distance/technology-enhanced learning for good and for ill.

Evaluate ways of attracting and maintaining a more diverse faculty. Evaluate the effectiveness of hiring incentives in particular.

Workforce

Calibrate the educational background truly necessary to succeed at work. Look at people who have succeeded and how they got there -- so people without certain backgrounds don't write off possibilities unnecessarily.

Research the nature of the labor shortage. How do salaries vary by ethnicity, with what other correlates?

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[14] Treisman, U. (1992). Studying students studying calculus: A look at the lives of minority mathematics students in college. The College Mathematics Journal, 23 (362 – 372).

Study how workforce organization affects participation. What is the availability/effectiveness of alternative work modes?

Research the effects of a diverse workforce on technology and technology markets.

Study the barriers/opportunities for economic development in minority communities.

4. Recommendations for Action

Despite the need for further research, several general action strategies recommend themselves to those making investments in change.

4.1 General exhortations

One size *doesn't* fit all; individuals, communities and institutions differ greatly. Programs and approaches that work in one setting may not work in others.

Involve affected groups in policy, planning and execution. Even in the unlikely event that an ivory-tower plan is actually well-designed, it is unlikely to be accepted without early involvement by its target population.

Leverage existing groups such as community technology centers, Alliances for Minority Participation, State and Urban Systemic Initiatives.

Evaluate! What worked and what didn't, and for which groups?

Expand, replicate and disseminate successful programs. Temper the tendency to value innovation above all else.

4.2 Initiatives

Economic investment

Develop venture capital resources for minority technology enterprises.

Develop both business and technical infrastructure for technology enterprise zones. Financial, human resource and consulting services, as well as real estate and telecommunications, can enhance the value of tax incentives.

Educational reform

Redress the "savage inequalities" in education. When vast disparities in classroom facilities and teaching resources exist, the technology gap cannot be closed.

Enhance the teaching of teachers about technology and how they can best use it in their classrooms. Teachers also need to be sensitive to their influence on equitable use of technology resources by their students.

Implement the lessons of "emerging scholars" programs.

Remove artificial barriers in admissions and curriculum, tailoring requirements to the actual needs of the discipline. Adapt curriculum to allow entry and re-entry from non-traditional backgrounds.

Broaden the culture of higher education, recognizing that students from different backgrounds may have different values, preferences and learning styles.

Recruiting and public image

Paint the possibilities of computing as more than isolated hacking. Computing professionals really can address important real-world problems, work in close contact with people, and have rich personal and community relationships.

Publicize role models. While they constitute a distinct minority, many members of under-represented groups are highly successful technologists and entrepreneurs.

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Sources of statistical information and reports on the web:

Digital Divide Clearinghouse
http://www.helping.com/digital/dd_about.adp

The Community Technology Centers' Network (CTCNet)
http://www.ctcnet.org/

Americans in the Information Age Falling Through the Net
http://www.ntia.doc.gov/ntiahome/digitaldivide/

Social and Economic Implications of Information Technologies:
A Bibliographic Data Base Pilot Project (Road Maps)
http://srsweb.nsf.gov/it_site/index.htm

National Center for Educational Statistics
http://nces.ed.gov/help/sitemap.asp

NCES Data Sources
http://www.nces.ed.gov/pubs/ce/c97009.html

School and Staffing Surveys, National Center for Educational Statistics
http://nces.ed.gov/surveys/sass

The Information Technology Workforce Data Project
http://www.uefoundation.org/itworkfp.html

Organizations

National Consortium for Graduate Degrees for Minorities in Engineering and Science, Inc. http://www.nd.edu/~gem/

Black Data Processing Associates
http://www.bdpa.org/

National Action Council for Minorities in Engineering (NACME)
http://www.nacme.org

Society of Hispanic Professional Engineers
http://www.shpe.org/

Digital Sojourn
http://www.digitalsojourn.org/
Digital Sojourn is a non-profit organization working to diversify the groups able to participate in and benefit from technology through workshops, networking and policy development.